Implementation of Enhanced Radiance Bias Correction in the NCEP's Data Assimilation System

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The enhanced radiance bias correction scheme (Zhu et al. 2013)) was implemented with the latest T1534 Global Forecast System (GFS) upgrade in December 2014 at the National Centers for Environmental Prediction (NCEP). The enhanced scheme simplifies the operational suite, replacing the original two-step procedure (Derber and Wu 1998) with a single variational procedure, obtaining both the scan-dependent and air-mass dependent components along with the control variables within the Gridpoint Statistical Interpolation (GSI) data assimilation system.

One new feature in the enhanced scheme is the bias initialization step. Any new radiance data can now be used directly with the initial bias correction set to be zero. Moreover, adaptive background error variances of the radiance bias predictor coefficients are constructed. Combined with the modified pre-conditioning, which speeds up the GSI minimization convergence rate, and the new bias initialization step, the adaptive error variances offer the GSI the capability to automatically detect any new, missing or recovery of radiance data and to initialize any new radiance data. This new capability facilitates the efforts of re-analysis projects. Figure 1 displays the time series of the error variance of the global offset (red line) versus the number of radiance observations (green line) for AIRS channel 22 on AQUA. The error variance decreases rapidly to about $2.0 \times 10^{-5} K^2$ when adequate data is available, but jumps up above $6 \times 10^{-5} K^2$ twice when the observation number drops to zero, and then comes back down again when the observations recover.

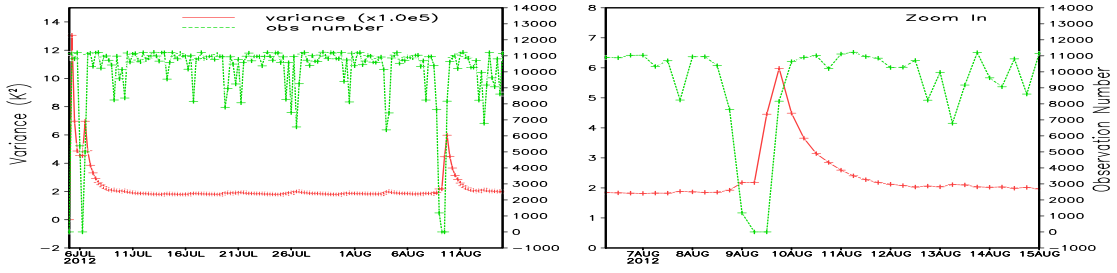

Figure 1. Time series of the background error variance of global offset (red line) and the number of radiance observations (green line) for AIRS channel 22 on AQUA (left panel). Zoomed in figure (right panel).

Another important new capability is the passive channel bias correction with a new approach formulated at the end of the analysis inside the GSI. This capability provides a very efficient way to obtain the bias estimate of any radiance data that are not used but monitored for future use, such as the data from Suomi National Polar-orbiting Partnership (NPP).

A new emissivity sensitivity predictor term has also been added to account for the land/sea difference, as the upgraded Community Radiative Transfer Model (CRTM release 2.1.3) development improves the microwave sea surface emissivity model. An example of OmF before/after bias correction for AMSUA channel 1 data from NOAA19 is given in Fig. 2 at 00Z Aug. 1, 2012. The combined effect of the two analysis components on the temperature analysis field at 700mb is presented in Fig. 3, where the upper left panel shows the analysis from **CTL** with the original radiance bias correction scheme and CRTM, the other panels are the analysis differences from the **CTL**: the lower right panel is from **CRTMonly**

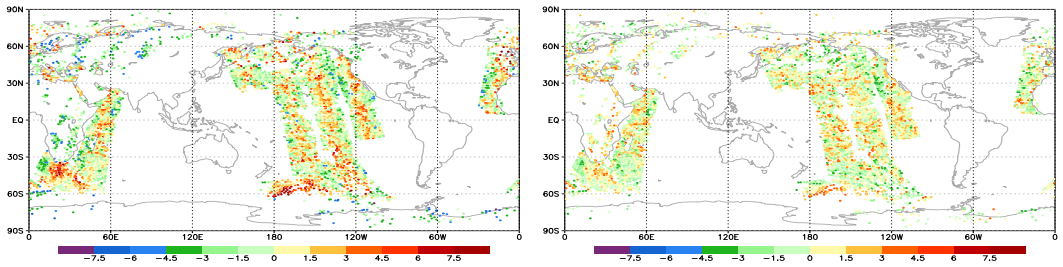

Figure 2. OmF for AMSUA channel 1 data from NOAA19 at 00Z Aug. 1, 2012: before bias correction (left), and after bias correction (right).

using the original bias correction scheme and upgraded CRTM, and the two other panels are from two slightly different configurations, **ERBCwCRTM** and **ERBCwCRTMn**, using both the enhanced radiance bias correction scheme and the upgraded CRTM. It has been known that our previous operational system has warmer temperature analyses over the southern higher latitudes at lower vertical levels when compared with the ECMWF analyses. It is seen that the use of

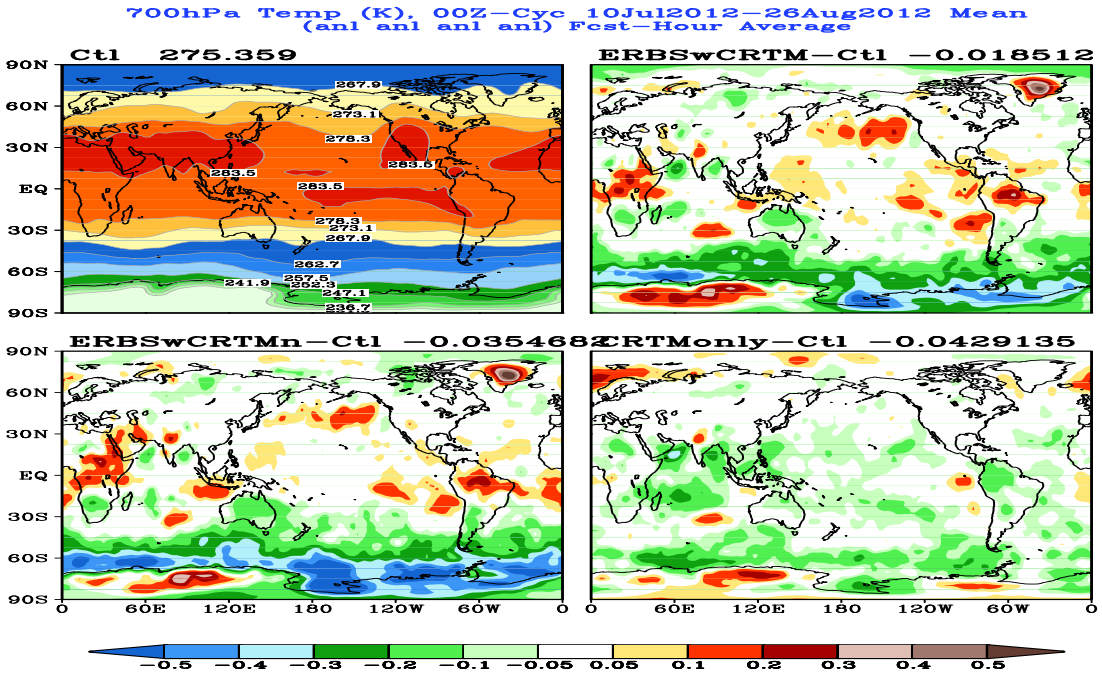

Figure 3. Mean temperature analysis field at 700mb for the **CTL** (upper left) and the analysis differences between each experiment and the **CTL** during the period from July 10 to Aug. 26, 2012: **ERBCwCRTM** (upper right), **ERBCwCRTMn** (lower left), and **CRTMonly** (lower right).

the CRTM release 2.1.3 reduces the warm bias by about $0.2K$ at southern higher latitudes, and turning on the enhanced radiance bias correction on top of the CRTM release 2.1.3 further reduces the magnitude of the warming (by as much as $0.5K$) and expands the cooling to much larger areas. The experiment results show that the enhanced radiance bias correction works well with the upgraded CRTM and provides additional significant forecast skill improvement. More details can be found in Zhu et al. 2014.

References

Derber, J. C., and W.-S. Wu 1998. The use of TOVS cloud-cleared radiances in the NCEP SSI analysis system. *Mon. Wea. Rev.*, **126**, 2287-2299.

Zhu, Y., J. Derber, A. Collard, D. Dee, R. Treadon, G. Gayno, and J. A. Jung 2013. Enhanced radiance bias correction in the National Centers for Environmental Prediction's Gridpoint Statistical Interpolation Data Assimilation System. *Q. J. R. Meteorol. Soc.*, DOI: 10.1002/qj.2233

Zhu, Y., J. Derber, A. Collard, D. Dee, R. Treadon, G. Gayno, J. Jung, D. Groff, Q. Liu, P.v. Delst, E. Liu, D. Kleist, 2014: Variational bias correction in the NCEP's data assimilation system. *The 19th International TOVS Study Conference (ITSC-19)*, Jeju Island, South Korea, March 25-April 1, 2014. [Available online at http://cimss.ssec.wisc.edu/itwg/itsc/itsc19/program/papers/10_02_zhu.pdf]